Saskatchewan Agriculture

Soils and Crops Branch

Legume Inoculation

ISBN 0-88656-466-2

Introduction

Legumes have a unique ability to take much of their nitrogen (N) directly from the air. These plants team up with a soil bacteria called Rhizobium, which live in special structures (called "nodules") attached to the roots. The rhizobia capture, or "fix" the nitrogen gas that is a normal component of soil air around the roots. The rhizobia then release the N to the legume plant in exchange for sugar. Some of this N is transferred to the soil as legume stubble and roots decompose. All of the plants listed in Table 1 are capable of fixing N.

In prairie agriculture, we can utilize N fixation to reduce fertilizer N inputs. This can be done by coating ("inoculating") legume seed with a commercial inoculant just prior to planting. Commercial Rhizobium, when properly applied, will ensure that every plant/bacteria unit in the field is fixing N, and fixing at a high rate. An alfalfa field that has not been inoculated might fix some 5-15 pounds N per acre per year, because a few native Rhizobium will be present in the soil. That same field, if properly inoculated with a commercial Rhizobium, would fix 30 to 60 pounds per acre per year. Under ideal conditions, fixation can exceed 100 pounds per acre.

Inoculation provides other benefits as well. Nodulated legumes are more drought tolerant than non-nodulated plants because they use water more efficiently. In addition, fixed N availability is synchronized to plant growth. As the plant gets larger, more fixed N is available to it. None of this N is wasted.

Table 1

Some representative members of the legume family. All of these are capable of fixing nitrogen, if given the correct inoculant.

alfalfa
bean
caragana
chickpea
clover
fababean
field pea
lentil
lupine
sainfoin
soybean
sweetclover
sweet pea
tangier flatpea
trefoil
vetch

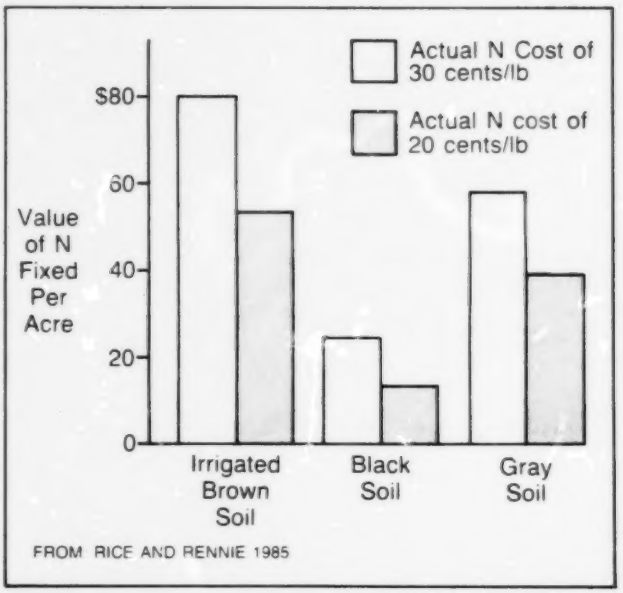
Effects on Yield

Recent work on field peas by the University of Saskatchewan has shown that inoculation can increase total dry matter yield by up to 65% over an uninoculated control crop. This average was derived from two varieties, tested at four different sites, in 1984 and 1985. Effects on yield will vary depending on crop, variety, location and previous history of the field.

The value of nitrogen fixation in alfalfa was documented in an Alberta study. Results on Table 2 show that inoculation of alfalfa can return $15 to $80 of free N per acre, per year.

Table 2

Estimate of annual value of N fixed by a pure alfalfa stand on three different soil types, using two different N prices.



FROM RICE AND RENNIE 1985

Information prepared by:
Don Gayton
Forage and Range Management Specialist
Saskatchewan Agriculture

3m 04/87

The Inoculant

Rhizobium inoculant is currently produced abroad and shipped to Canada each spring. It is available through seed dealers and farm supply outlets. Inoculant is a **live culture** with a short shelf life, so retailers bring in limited amounts each spring. Check the expiry date on the bags, and don't buy outdated inoculant. For fall plantings of crops like alfalfa, growers should purchase inoculant in the spring and arrange for cold storage until they are ready to use it.

Legume inoculant, when properly applied, gives an excellent return per dollar invested.

Rhizobium is crop specific: for instance, pea inoculant is totally ineffective on alfalfa, and vice-versa. The bags are clearly marked, so make sure to get the type that is specific to your crop.

Keep in mind that the inoculant can be killed by heat and/or sunlight. It **must** be kept cool until use. An unheated outbuilding will provide good temporary storage in the spring. Moderate freezing temperatures will not affect inoculant viability. For longer storage periods, a refrigerator is ideal, but freezers may also be used.

Stickers

Inoculant is a dry powder that is mixed with the seed just prior to planting. In order to be effective, it must be glued on to the seed, so a "sticker" is used to bind the two together. Commonly used sticking agents are dilute sugar water, molasses, syrup, milk, wallpaper paste, soda pop, etc. Work at the Agriculture Canada Research Station in Swift Current has shown ordinary powdered skim milk to be very effective. The milk solution not only acts as a glue, it also provides nutrients to the rhizobia as they wait for the seed to germinate.

Commercial stickers are available, but difficult to obtain. Be sure to avoid substances like milk replacer, which may contain antibiotics.

Precise amounts of milk sticker are not important. Just mix the skim milk powder according to the package directions. (Do not use hot water since this may kill the inoculant). Next, dribble (or spray) the milk on the seed. The objective here is to moisten the surface of each seed, and let the excess drain off. Some means of turning the seed is helpful to ensure complete wetting.

Mixing the Inoculant

Once the seed is wetted, add the inoculant. Follow the manufacturer's instructions for proper amounts. Many pulse growers routinely double the recommended rate to ensure complete seed coverage. Since the inoculant is a fine, dry powder, it will coat the wetted seed, allowing it to flow easily again.

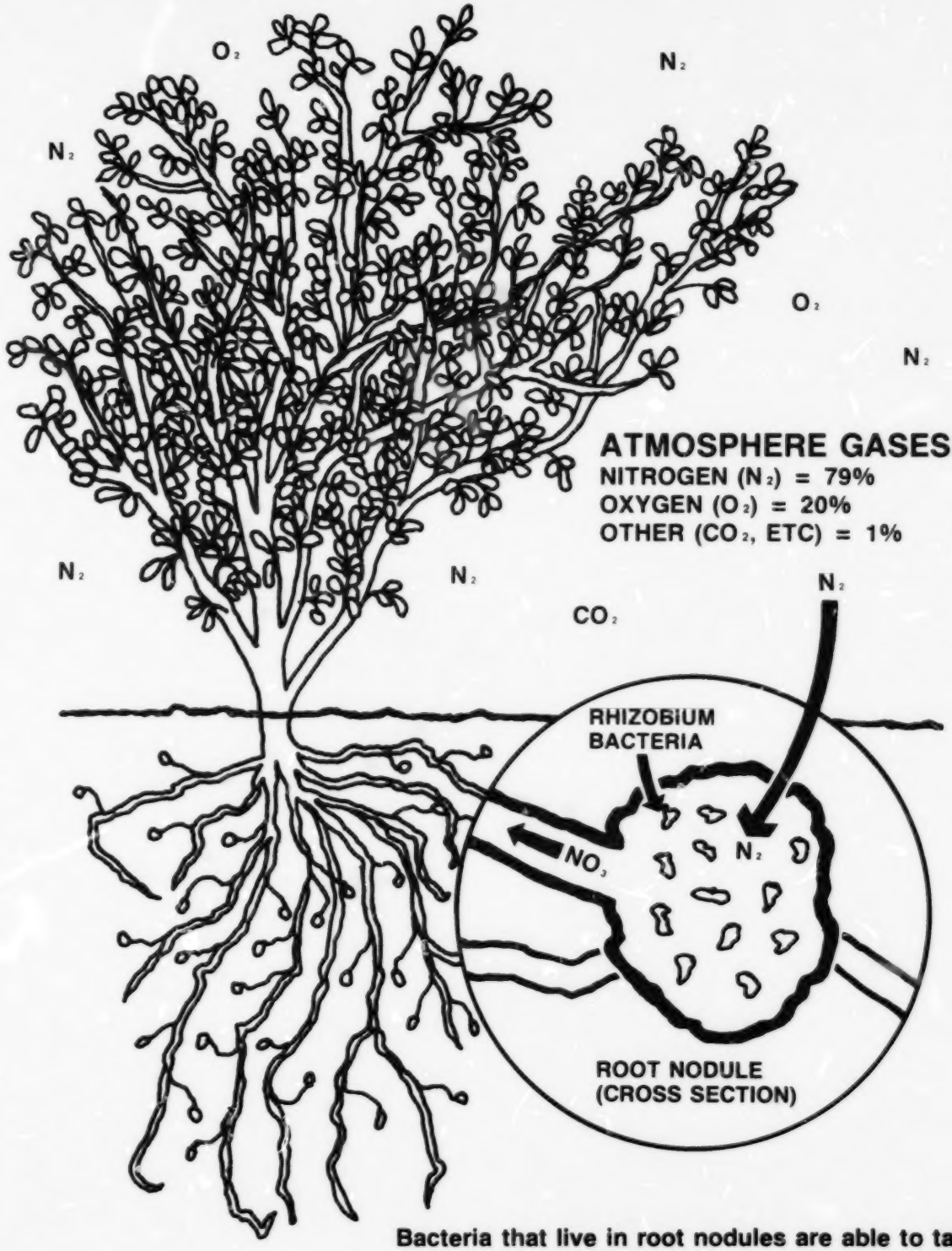
Small batches of wetted seed can be inoculated manually by mixing the seed in a large container or on a polyethylene sheet. Add half the inoculant, turn the seed thoroughly, and then add the rest, turning it again. For larger amounts of seed, augers are frequently used. Inoculant and sticker are dribbled on to the seed as it flows into the auger. Cement mixers and ice augers have also been successfully used. Once producers understand the principles of inoculation, they can easily develop a mixing system that fits their particular operation.

Corn syrup has been a popular sticking agent for lentils. A basic recipe is as follows: mix 1-2 litres of corn syrup into 5 gallons of warm water. Wet the seed thoroughly. Then mix the inoculant so each seed is covered. Four large (2.8 kg) bags of inoculant will do 4800 pounds of lentil seed.

Inoculant can be mixed directly into the sticker solution, but this sytem has two drawbacks: 1) the dry inoculant powder tends to stay in lumps in the solution, and 2) complete seed coverage is difficult to obtain.

Home gardeners should take advantage of N fixation by buying individual bags of inoculant and hand-mixing it with their pea and bean seed. Quite often dramatic increases in vigor and yield will be noted.

THE LEGUME-NITROGEN CYCLE



Bacteria that live in root nodules are able to take nitrogen gas from the air and convert it to nitrate nitrogen for the plant.

Table 3

Effect of Sticking Agents on Nodule Production and Whole Plant Yield in Soybeans

Sticking Agent	Nodules Per Plant	Plant Yield (mg)
Uninoculated Control	0	350
Water	39	779
Sugar Solution	83	751
Honey Solution	94	854
Nitracoat (commercial)	109	911
Powdered Milk Solution	96	1081
Sig. Difference (0.05)	29	200

From: Elegba and Rennie, 1984.

Seeding

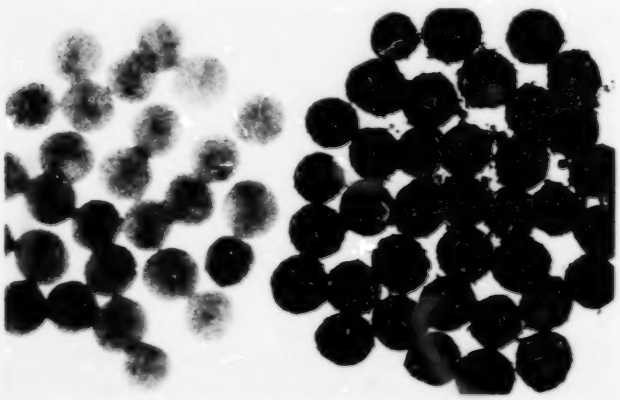
Seeding of inoculated seed can proceed normally, with some precautions:

- recalibration of the seeder may be necessary, since inoculated seed will flow more slowly than uninoculated seed.

- Don't mix inoculated seed directly with phosphorous fertilizer, because the high concentration of fertilizer salts will kill the rhizobium.

- All seed treatments (except possibly Thiram), are toxic to inoculant, so increase rates of inoculation if you are working with treated seed.

- If seeding is delayed, do not leave a loaded truck or seeder exposed to direct sunlight for any length of time. If the truck is tarped and kept in a cool place, rhizobia on the seed will remain viable for 3-4 days. If stored longer than that, seed should be re-inoculated.



Uninoculated lentil seed is on the left, inoculated on the right.

- If alfalfa seed is to be broadcast, increase the rate of inoculation.

- If seeding conditions are poor (too wet, too dry, too cold, etc.) increase the inoculation rate, because some of the Rhizobia will die off. Acid or low pH soils do not favor rhizobium growth, so inoculation rate should be increased under these conditions as well. Don't hesitate to double or even triple the recommended rate: inoculation is cheap and it provides a lasting return.

Field Checks

You can check to see if your legume crop is fixing N by doing a field check in early summer before flowering. dig up a few plants and gently shake the soil away from the roots. You should see numerous small, swollen nodules on the roots. The inside of the nodule should be pinkish in color. (Absence of the pinkish color means that the nodule is ineffective.)

Re-inoculation

Many producers wonder if they need to inoculate seed that is going into a field that was successfully inoculated to the same crop previously. There is no conclusive research on this question. In general, rhizobia tend to be long-lived in the moister Parkland soils, and short-lived in the drier soils of central and southern Saskatchewan. In the case of annual legumes on Parkland soils, if complete and effective nodulation has occurred once, then the producer can wait two to three years before inoculating again. For all other situations, it is probably best to re-inoculate every time you seed a legume crop.

Custom Inoculation and Pre-inoculated Seed

Several companies in Saskatchewan offer custom inoculation services for crops like lentils and peas. They are set up to handle large volumes of seed and many pulse crop growers make use of their services.

Recently, pre-inoculated forage legume seed has come on to the market. The seed is pre-inoculated by the company and then shipped in bags to retailers. Pre-inoculated seed is very convenient, but some inoculant viability problems have been encountered with seed that was not heavily coated. Pre-inoculation technology will no doubt improve in the future.